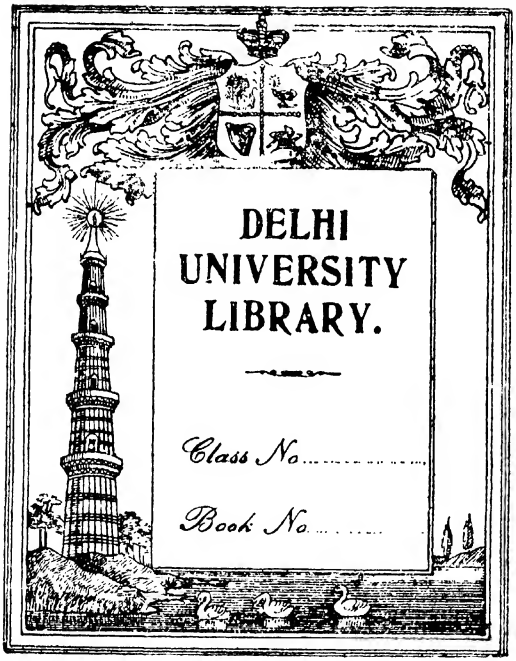
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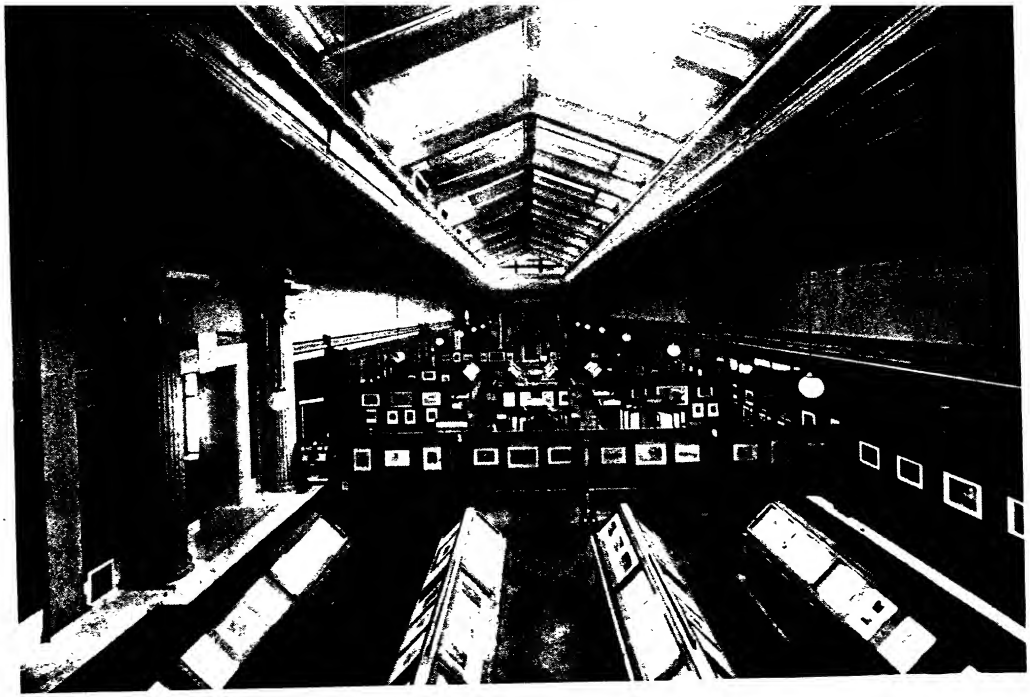

Exhibition Gallery, Department of Prints and Drawings, British Museum

THE CONSERVATION OF PRINTS, DRAWINGS, AND MANUSCRIPTS

BY

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PREFACE

THE present book is designed as a sequel to *The Preservation of Antiquities*, to which it conforms, as far as possible, in style and treatment.

Prints, drawings, and manuscripts seldom require urgent attention in the laboratory with a view to preventing speedy decay; on the other hand, they present a fragile and very easily damaged surface which is liable to deteriorate in various ways unless properly cared for. A study of the materials used by the artist or craftsman and of approved curatorial methods —as, for example, of mounting, storage, and exhibition—is essential to their conservation in good condition.

The opening chapters of the book are devoted to these subjects: the main types of decay are described, the general scheme being to deal, first of all, with materials in good condition, and then to consider the chief manifestations of deterioration, concluding with a chapter of a severely practical nature devoted to methods of cleaning and repair.

Much of the subject-matter has been inspired either by correspondence or consultation in connexion with official work at the British Museum, and acknowledgements are due to Mr. A. E. Popham, Deputy Keeper in the Department of Prints and Drawings, to Dr. Alexander Scott, F.R.S., and many friends, as also to many standard books of reference which it is hoped have been adequately noticed in the text.

The studies which form the basis of the present work were first published in *Mouseion*, Official Organ of the International Museums Office, Paris, and my thanks are due to the Editor for permission to recast the material in its present form.

June 1936. H. J. P.

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CHAPTER I

MATERIALS AND THEIR PERMANENCE

THE conservation of the various kinds of prints, drawings, manuscripts, and such like, depends in the first instance on the characteristics of the materials composing them—paper, vellum, inks, pigments, paste, &c., and these materials, though limited in number, vary greatly in quality and permanence. The study of materials is not without intrinsic interest, and it forms the basis of all knowledge of any value in preservation work. If, for example, a water-colour drawing be executed in evanescent pigment or on inferior paper, such facts will certainly be of significance when it comes to cleaning, and the successful preservation of the drawing, which may be of unique value, will depend on a proper appreciation of its physical and chemical condition. Moreover, it is important to know which materials are best suited for use in mounting as well as in repair work, and the technician must therefore accustom himself to consider the qualities and condition of his materials from the very beginning.

For the conservator or technical expert who has the care of maintaining collections of prints, drawings, and manuscripts in good condition, classification according to type and style of art is of secondary importance. His first call is to study the chemical and physical composition of his charges, then the technique of manufacture, and, finally, the physical history of the specimens, in so far as it can be determined, from the time they were completed as works of art till they took their place in the collections. Should he omit to attach due importance to any one of these three studies, he is liable to fall into grave errors in cleaning, mounting, storage, and exhibition, as well as in the diagnosis and treatment of decay.

The present chapter is devoted to the consideration, from the point of view of their permanence, of the more important writing, drawing, and painting materials. The notes and observations are to be taken as suggestive and in no sense

exhaustive, and they will be found to apply to a very large and heterogeneous assortment of museum specimens. From a consideration of materials it will be a natural step to the objects themselves; in particular, to the consideration of questions relating to mounting, storage, and exhibition, and to practical methods of dealing with various forms of decay, aspects of the subject which are dealt with in detail later on.

1. *Paper.*

Paper may be described as an artificially prepared sheet of felted vegetable fibre. The best papers are manufactured from linen and cotton rags, although all kinds are found in collections of prints and drawings. The standard process of paper manufacture requires in the first place that the rags be completely disintegrated, yielding a pulp which is bleached to an approximate white. Before this pulp is manufactured into paper it may be made quite white by the addition of a little smalt (cobalt silicate), and then 'loaded' with kaolin (China clay) or with calcium sulphate, so as eventually to take a good surface in the calender. If the paper is to resist ink it must be sized; this may be done in the pulp stage. Glue is commonly used for the purpose; aluminium resinate may be precipitated in the fibres by stirring the pulp with sodium resinate and excess of free alum: starch is generally added to help the fibres to unite.

The best drawing-papers are not loaded, but they have to be sized to prevent colour spreading on application (as it would upon blotting-paper). They may be tub-sized, that is to say sized by immersing the finished sheets in very thin glue.

In hand-made papers one sheet is made at a time. A thin aqueous suspension of pulp is shaken in a wire-cloth mould, and this causes the fibres to unite, forming a continuous sheet. As the fibres lie in every direction, the material is uniform in character; when damped along two edges at right angles the margins of hand-made paper cockle in the same manner. Machine-made paper as a rule does not do so, as it possesses a distinct grain owing to the cellulose fibres having arranged themselves along the lines of flow as the pulp passes through

the machine; machine-made paper will frequently tear more easily in one direction than in another.

The quality of paper depends ultimately on the source of the materials used in manufacture, the length of the cellulose fibres determining the efficiency of matting. The long bast fibres of the mulberry tree (*Broussonetia papyriferia*, Vent.) provide very strong papers of light weight (Japanese Tissues) which are invaluable in repair work. On the other hand, certain materials such as esparto grass, straw, or mechanical pulp yield papers which are easily torn through the slipping of their comparatively short fibres; consequently, these have to be heavily sized, and from the point of view of permanence, this is undesirable, as size is a good nutrient-material for moulds. Some water-colour-papers have a quality which has been imparted by tub-sizing in too generous a fashion; the large concentration of size on the surface of the paper causes it, in time, to become brittle and the colours suffer a loss in tone.

Papers which are heavily loaded should be regarded with suspicion. Such sheets are liable to stick together when damp, forming a solid mass.

The bleaching process to which all paper pulp is subjected in the course of its manufacture into paper, has a powerful sterilizing action on the raw materials. If this should have been imperfectly carried out, the finished paper may be contaminated with mildew or bacteria through primary infection, i.e. from spores which have persisted from the pulp stage. The infection may pass unobserved at first, but will almost certainly give rise to staining later.

Some papers are acid, or contain traces of the bleaching solution. These soon become brittle and perish.

It will be appreciated, therefore, that papers and cards differ considerably in composition and stability. The conservator has under his care papers of all kinds: thin, heavy, coloured, brittle, and, perhaps, stained and mildewed. He can, of course, take steps to sterilize and to strengthen them where necessary, but it should be a primary duty to ensure that they are not exposed to further infection of any kind whilst in his keeping.

For this reason it is very important to see that infected material is isolated and that only material which is entirely sound and good is employed in the print room or for the laying down of manuscript matter in the library or gallery. This point can hardly be over-emphasized: it applies to the backs of pictures, the lining of boxes, &c., with as much force as to mounts and papers which are constantly exposed to view.

One further point calls for mention at this stage, namely, that paper is very susceptible to damp. Old papers are commonly found to be absorbent and brittle. They have slowly attracted moisture which has helped to promote the gradual atmospheric oxidation of the cellulose and the size, and, when in due course the latter has perished, the paper has been easily stained.

Under approved conditions of storage, paper may be described as a permanent material. The least permanent kind is probably newsprint which, containing ground wood and crude fibres, quickly discolours and becomes brittle, and this may be observed after a few days' exposure to sunlight. To meet this difficulty special limited editions of some newspapers are printed on high-grade paper for the permanent files of libraries.[1]

Decayed and damaged papers in all conditions may be handled and generally restored to a considerable extent by those who have acquired the technique; the novice is usually surprised when he first hears that thin sheets of paper can actually be split in two to show, for example, material written or drawn on each side of the sheet, and margins may be welded to paper with such skill as actually, sometimes, to deceive the eye of the expert. The technical processes are, of necessity, limited by the nature of the paper and of the subject, according as it is a document, print, engraving, &c.

2. *Parchment and Vellum.*

Parchment and vellum are of great importance because of their use for manuscripts, binding materials, prints, and maps.

[1] See also Scribner, *Preservation of Newspaper Records*. National Bureau of Standards Publication No. 145, Government Printing Office, Washington, U.S.A., 1934.

They have been in favour for writing and illuminating and, to a lesser extent, for printing from engraved plates and from woodblocks; their use in binding depends to a certain extent on the fact that when damp they can be readily moulded and tooled.

Although parchment is prepared from the skin of sheep and goats, and vellum from calf, it is often difficult in practice to distinguish which is which even by the microscope, and no doubt other animals have yielded kindred materials having apparently the same characteristics. It will suffice to consider vellum as the type-material whose properties are characteristic of others of the series.

Vellum is prepared by stretching the skin and subjecting it to the depilatory action of lime; it is finally rubbed with pumice and burnished. Fine qualities are made from the skin of new-born lambs and goats. An adhesive known as parchment size may be obtained by extracting the substance with hot water.

Vellum, when it has been carefully preserved, is extraordinarily permanent, as may be seen by examining any collection of old manuscripts. On the other hand, it is just as evident that excess of moisture and heat causes expansion, and wrinkling of the skin as well as discoloration, and that excessive dryness makes vellum hard and brittle. As might be expected, its properties lie between those of paper and leather.

While vellum bindings may with advantage be treated with a non-staining leather dressing, the manipulation of vellum prints and documents requires the employment of processes similar to those adopted with prints and drawings on paper, and such processes are all that concern us at present. To restore a vellum manuscript which has been destroyed by water, it is necessary to separate the leaves and clean, flatten, and, if necessary, repair, each sheet separately. The writing, &c., sometimes becomes more legible as a result; a successful restoration cannot be attained by any other form of treatment. To attempt to straighten the curled sheets by compressing the book in a book-press, for example, would simply result in accentuating

the damage, if indeed the press were strong enough to overcome the great elasticity of the material.

3. *Inks.*

The earliest types of ink, and the most permanent, are those having a basis of carbon or lamp-black which has been ground in a medium of size or of vegetable gum. Such inks, though still in use in China and the Near East, have been largely superseded by inks of the iron-gall type in Western countries, and are now used only by artists and draughtsmen in the form of so-called Indian or Chinese ink. The transition in the West, as might be expected, was gradual. While iron-gall inks were actually employed for writing, even before the seventh century A.D., both types of ink were in common use for many centuries, and for this reason the nature of an ink cannot be deduced with certainty from a knowledge of the date and provenance of a manuscript.[1] The inks, of course, can easily be identified by chemical methods, but this affords little help because a manuscript in a carbon ink is not necessarily of any great age.

Sepia, which is obtained from the cuttle-fish (*Eusepia officinalis*), is now mainly used by artists, although it had at one time a limited use as a writing fluid. Bistre, made from the soot of burning wood, resin, or peat, is the name given to a material which is similar in appearance to sepia, so much so, in fact, that it is often impossible by merely inspecting a drawing to say which of the two pigments has been used.

Printer's inks and litho-inks are essentially pigmented varnishes containing a drying-oil. Carbon is used as the pigment where blacks are concerned, and there is a little admixture of burnt umber or ochre when a warmer or brownish tint is required. In the older methods of manufacture the oil was actually heated until it emitted inflammable vapours which were set on fire, the product being a thick syrupy liquid. This

[1] The writings of Dr. C. A. Mitchell are authoritative, e.g. *Documents and their Scientific Examination*, also *Inks, their Composition and Manufacture*: Publishers, Griffin & Son, London.

method is still employed for the production of oils used in copper-plate printing.

Printer's inks and litho-inks are permanent. They have the weakness, however, that the oily medium (vehicle or binding material) is a nutrient for moulds. Certain kinds of engraving may have much ink present (mezzotints), and these should be regularly inspected on this account. Pure black carbon inks are permanent, carbon being chemically inert; sepia is uncertain; bistre is definitely impermanent. When sepia or any ink of the carbon type (e.g. bistre) fades, there is no satisfactory method of restoring it to a state of legibility short of retouching; the cleaning of a drawing in brown ink should be undertaken with the greatest caution.

The medium (binding material) may play an important part in the life of an ink or pigment. If it be acid, the paper may rot, especially in parts where the writing or drawing is heavily executed. If the paper happens to be thin it becomes very delicate and liable to crack along inked lines. In such cases, when the paper is thin and brittle, the only satisfactory way of preserving it is to lay it down on Japanese tissue.

A different problem arises when there has been insufficient medium present in the ink to wet the paper, or when the paper has been greasy at the time of writing or drawing. The cellulose fibres are then stained superficially only, and impermanence results because the pigment, whatever its nature, is confined to the extreme surface and is very easily lost by rubbing or by soaking in water. Although quite general in its occurrence, this type of decay has been noted especially in early German woodcuts. The only cure in this case is to add a binding medium. This may take the form of parchment or glue size applied from the back of the paper; or the front of the paper may be sprayed with a transparent fixative depending on the type of work to be treated. The following cellulose acetate solution obtainable from Cellon Ltd., Upper Ham Road, Kingston-on-Thames, Surrey, has been found suitable for spraying:

{'Cerric' Transparent Solution 'D 485', 1 vol.
'Cerric' Thinning Solution, 'T 6', 3 vols.}

The subject of inks may be closed with a reference to iron inks. These vary considerably in permanence, as for centuries they were made from oak-galls by rule-of-thumb methods. Iron inks are liable to become faint and almost colourless with age, especially when the paper or vellum has been subjected to damp. This is because of the gradual decomposition of the tannic acid with an accompanying reduction of the black or deep-brown pigment to a pale-brown and ultimately pale-green form, and in advanced decay the ink may completely disappear. It is true that even in this condition, it may sometimes still be decipherable under ultra-violet illumination. And so long as the iron remains in the paper it should be possible to revive the ink by chemical methods. Repeated soaking or exposure to damp causes the ink to be spread in the paper; when ink is in this condition and is eventually restored to its original intensity, the writing is often so blurred as to be quite illegible.

It will be noted that inks provide some difficult problems in conservation (only a few of which have been touched on here), and that special care is necessary in dealing with certain of them which are fugitive.

4. *Water-colour Pigments.*

Pigments ground in gum which may contain a little glycerine and honey form the moist colours known as water-colours, and when these are applied to paper the fibres pick up the pigment, and become stained as the moisture evaporates. Effects are obtained by mixing and by superimposing washes of different tints, but not all pigments are compatible, a decided blackening being obtained, for example, by the mingling of cadmium yellow and flake white. This is because the lead of the latter takes sulphur from the cadmium yellow, being transformed into lead sulphide, which is black. 'Muddy' colour results from the admixture of vermilion with Antwerp blue or madder lake. Other striking examples of bad mixing could be instanced. The curator, however, is concerned rather with the *fait accompli* than with the practical side of picture-making in which he can

easily obtain some technical experience if he desires. The chemical interaction of certain pigments has a bearing on the gradual lowering in tone which is characteristic of body-colour painting and of the works of particular artists, and is the direct cause of a type of smudging which can be traced to the use of injudicious mixtures. These two forms of decay may develop imperceptibly and be aggravated by other influences which have now to be considered.

Lowering in tone is hastened by exposure to sunlight and damp. Special attention has been devoted to the bleaching action of sunlight upon water-colours, and it has been established that this is most active in presence of moisture. Visible light-rays play an important part in bleaching, which is not caused solely by the action of ultra-violet rays as is sometimes stated or implied. It will suffice here to refer to two of the original papers concerned with the fading of water-colours.[1]

Colours may be decomposed by oxidation, hydrolysis, fermentation, &c., as in the case of Indian yellow, for example, which may become brown, emitting a volatile agent which influences adjacent colours and may even stain adjacent pages in a book of miniatures. A green colour containing this pigment may become deep blue. A similar result has been noticed in the case of a pastel which was attacked by fungi (mildew), a green becoming light blue (owing to the destruction of the yellow constituent) and a light brown fading completely away under the influence of the growing mycelia.

The most striking cases of decay, however, are caused by the action of sulphuretted hydrogen gas, which is present in the atmosphere of towns, and which we know as the active agent in the tarnishing of silver. Its action on lead pigments is equally disastrous, white lead and red lead being converted into the black sulphide already referred to. Fortunately, the black stains on Flake White (which may cover the picture when this pigment has been used as body-colour) may be

[1] Russell and Abney, *Report on the Action of Light on Watercolours*, H.M. Stationery Office, Cmd. 5453, 1888; Macintyre and Buckley, 'The Fading of Watercolour Pigments', *Burlington Magazine*, July 1930.

easily dispelled by the action of hydrogen peroxide. Under such treatment the black sulphide is oxidized to sulphate of lead, which is white and permanent. That the blackening is confined to the extreme surface of the pigment is proved by the action of hydrogen peroxide on blackened red lead; this results in the formation of a film of white sulphate of feeble covering power which scarcely shows above the original red colour so revealed. There are variations of technique in applying this reagent which will, in due course, be described; the processes are amongst the simplest which the conservator is called upon to perform and they are by far the most striking in result, because sometimes in a few seconds an apparently hopelessly dirty drawing can be restored to its original brilliance and the colours will survive the closest scrutiny. No evidence remains of what at first appeared to be irretrievable decay.

Vermilion sometimes blackens, but from a different cause. It is wrong to suppose that sulphuretted hydrogen gas can affect vermilion; the blackening of vermilion is a physical change, and while it is not known what causes it to take place it seems certain that darkness promotes the decay. If a blackened pigment does not at once respond to hydrogen peroxide it is safe to presume that blackened lead is absent. A persistent black stain may indicate the presence of vermilion in black form, or of a tarnished silver illumination such as occurs so frequently in Indian and Persian miniatures.

It is undesirable at this stage to describe the details of cleaning and restoration, but it should be pointed out that some important processes depend on the use of aqueous solutions, and one might be pardoned for considering that these might be dangerous to colours which have actually been applied to the paper with water. It is a matter of practical experience that the *average* water-colour in time becomes fixed on the paper so that the pigment is very difficult to remove by plain water, a fortunate observation, as it allows the restorer a certain latitude in manipulation.

With water-colours the greatest care must nevertheless be

exercised in the choice of cleaning technique and in the use of chemical reagents: few processes may be applied generally, and mistakes may be accompanied by change in colours, by staining, or by bleaching, resulting perhaps in the irretrievable loss of delicate lake colours. Mistakes of this kind cannot be rectified, and a certain practical experience on experimental material is therefore essential to the restorer who is entrusted with the cleaning of water-colour drawings. In the field of medieval illuminated manuscripts the problems of colour are increased many fold because of the variety and uncertainty in the composition of pigments. Many are fugitive or depend for their permanence on some trick of the artist which can only be appreciated by specialized study. Those interested are recommended to consult *The Materials of Medieval Painting*, by D. V. Thompson (George Allen & Unwin, Ltd., 1936).

5. *Other Drawing Materials.*

Pastels are compounded by grinding pigments with pipe-clay, the material being formed into sticks with an adhesive such as gum tragacanth. In pastel paintings the pigments are very lightly held to the ground, and although colours may be chemically stable, the pictures made from them are easily damaged by rubbing and even by mechanical vibration where such exists. The quality of the work is lost when any artificial fixative is employed (e.g. shellac, casein, or milk), but certain types of drawing become more stable with time, probably owing to the action of moisture and oxygen. Pastel and chalk drawings expose a comparatively large surface of pigment and agglutinant to the atmosphere; the gum or size is easily infected by spores, and hence their proneness to become mildewed. In this condition pastels may easily be sterilized but often only with great difficulty freed from discoloration caused by mould growth.

Pencil drawings are more stable. The graphite pigment is permanent, and although the drawing can be damaged by rubbing, especially when it is fresh, here again the fixing action of time is noticeable.

Silver-point and gold-point drawings seldom give trouble as regards preservation, but as the metallic pencils sometimes contain lead, which loses colour on decay (being converted to white lead, a basic carbonate), it is advisable to keep such drawings securely protected against contamination. They should on no account be stored in oak cupboards but in cupboards of some other material, preferably mahogany.[1]

[1] Cf. *The Preservation of Antiquities*, pp. 13–17.

CHAPTER II

MOUNTING, STORAGE, AND EXHIBITION

In order that collections of prints, drawings, and manuscripts may be kept in good condition, there must be a rational system of mounting (where applicable), storage, and exhibition, and by this is meant the standardization of sizes, styles, and even of routine.

Manuscripts are the most difficult group on which to generalize because of the diversity of species; the library technique will predominate here. When smaller documents, scrolls, &c., are stored in cases or boxes, these should be uniform in pattern and also in size in so far as conditions will allow.

In the case of prints and drawings the key to the situation lies in the mount. If a uniform system of mounting be adopted in which only a few carefully chosen sizes of mount are utilized, then storage cases, shelves, drawers, portfolios, picture-frames, &c., can be made to conform. Space is used to best advantage in such a simplified system. Development on these lines allows, also, of the free exchange of pictures between the students' room and exhibition gallery; it facilitates the arrangement of temporary exhibitions and, what is of the greatest importance, it simplifies the task of conducting changes in the hanging exhibition, frequent changes of this sort being essential to the conservation of material which is sensitive to light. Any other scheme would entail carrying a large and varied stock of picture-frames, and the mounting department would be eternally at work making adjustments involving unnecessary strain to prints and drawings. There can be no doubt, therefore, as regards the desirability of rationalization.

But the mount is justified on quite independent grounds. It is a necessity for exhibition purposes because material can be shown to advantage only when properly mounted in suitable style; the mount makes for safety in handling and prevents prints and drawings from becoming soiled, and it also affords protection from rubbing during storage. One can understand

the point of view of the authority who apropos of museum work wrote: 'You do not frame your picture, you frame your mount.' We shall now examine the principal styles of mount which are used in collections of prints and drawings.

1. *Specifications for Mounts.*

First comes the question of dimensions. Absolute uniformity in the size and style of mounts would be impracticable even if desirable, because of the differences in the size and condition of prints and drawings. The nature of the collection as a whole will determine the approximate dimensions of the few mounts chosen as standards and, on grounds of economy, the exact sizes will only be fixed after considering the sizes in which paper and boards are manufactured. Allowance has to be made for some slight marginal trimming. The point is illustrated by current data supplied from the two largest London collections:

Trade name	*Manufacturers' dimensions*	*Sizes adopted in British Museum*	*Sizes adopted in the Victoria and Albert Museum*
'Royal'	24 × 19 in.	22 × 16 in.	22½ × 18½ in.
'Imperial'	30 × 22 in.	27 × 20 in.	29½ × 21½ in.
'Atlas'	34 × 26 in.	32 × 24 in.	32 × 24 in.

A so-called 'half-imperial' mount (about 15 × 21 in.) is perhaps the commonest in use at the Victoria and Albert Museum. In the absence of a concerted plan one would not expect to find identity in working size in different collections.

Three styles of mount are in common use called, respectively, the *solid mount*, the *overthrow mount*, and the *window-mount*, and these refer to mountings in cardboard. Paper is used in a less formal kind of mounting known as *inlaying*, and this is employed in the case of a print or drawing which has no blank margin, and which would suffer irreparably if torn. Inlaying is subsidiary to mounting and is carried out as follows: cut a rectangular opening in a sheet of high-grade paper of similar weight to that of the print; enlarge the opening by chamfer-

ing its edges until the print fits neatly into place, and fix it permanently in position by applying paste around the edges. The ensemble will now appear like a single sheet of paper. Inlaying may suffice for material which is preserved loose in portfolios, but if an inlaid print or drawing is to be transferred to the Solander box collection (presently to be described) it requires to be properly mounted in card, and a mount of the overthrow type would then be adopted.

The practice of inlaying several small engravings in one sheet which is later bound as the page of a volume has sometimes been adopted with collections which are complete. Although at first sight it may seem logical and very convenient, it is to be discouraged owing to the difficulties that attend cleaning and sterilizing, should these become necessary.

The mention of *paste* calls for a slight digression. Of the many possible adhesives, it is necessary to choose one free from staining material and harmful preservatives. Good photographic mountants satisfy these conditions, but are too expensive to use in large quantities. On the other hand, cheap office pastes and adhesives supplied for hanging wall-paper must be avoided.

For general work there is nothing to surpass freshly-prepared flour paste ('bookbinders' paste') as it is easy to make and to apply and to remove again if necessary. It is prepared as follows:

Wheaten flour . . .	500 grammes
Alum	7 grammes
Water	2,250 c.c.
Formalin	7 c.c.

Mix the flour with a little of the water in an aluminium or enamel pan (inner lining of a double milk saucepan), the lumps being broken up with the hands to form a thick cream to which the alum is added. Boil the remainder of the water in a separate vessel and add it to the cream. The paste is now heated, not directly, but by water which is boiled in the outer saucepan; it is stirred thoroughly, and will soon thicken. After

about **10** minutes pour the paste into a wooden paste-tub and stir in the formalin. To prevent a crust forming as the paste cools place a sheet of paper on the surface of the paste and pour a little water on to it; tie a string across the tub to stroke the brush on, in order that it may not be charged too freely with adhesive. This paste keeps well for a week but, in practice, should not be used after it is four days old. It is rather too thick for mounting purposes and must be thinned with water as required.

Paste should be applied evenly and thinly so that it may dry quickly without souring, but there should not be so much water present as to cause the paper to stretch. Paste should be discarded as soon as it becomes sour and watery; in this condition it should never be allowed to remain in the museum.

We are now ready to mount our picture. The old way was to paste the back all over and 'lay it down' on a card, but this is never done nowadays; the mounting is accomplished by attaching the print by one or more pasted paper hinges or guards (generally four), depending on the style of mount to be adopted, and by this process it cannot suffer damage and may be easily removed again if necessary.

(*a*) *The Solid Mount.* To prepare a solid mount, the print or drawing is attached by pasted paper hinges in a 'box' prepared by pasting a cardboard ('3 sheet') frame to a sheet of cardboard ('4 sheet') of the same size as the frame (see Fig. 1). The back-board must always be thicker than the frame, the relative thicknesses being dependent on the size of the print and the type of mount, e.g. a comparatively large print would require a thick mount in order to prevent any chance of bending. Thick boards must always be employed in mounting pastels.

All mounts should be finished with rounded corners to avoid the chance of damage if they are carelessly dragged over the surface of adjacent prints by students during examination. This is done with the help of fine glass-paper, which should be rubbed along the edges of the cards also, until any roughness has been removed.

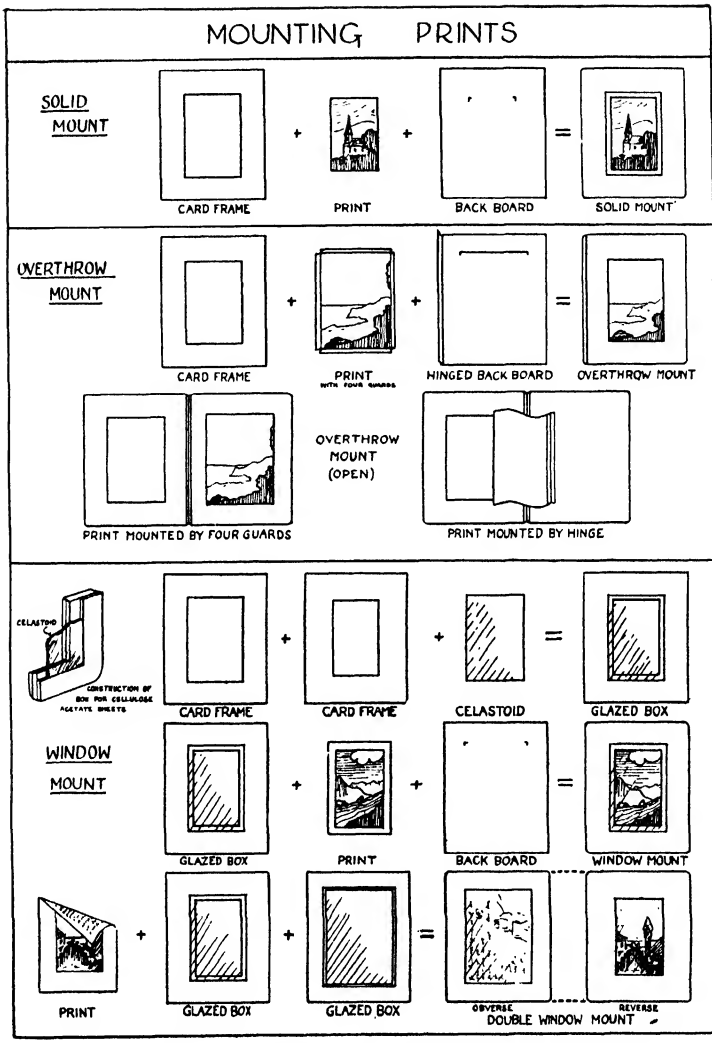


FIG. 1. Diagram illustrating methods of Mounting Prints

(*b*) *The Overthrow Mount.* When a print has a torn or damaged edge it is laid on a card by pasted guards of paper, and to this card a cardboard frame is hinged (by linen) so that normally the disfigurement is concealed by the frame. The frame may be opened to the left to expose the whole of the print for examination. Such an arrangement is known as an overthrow mount.

A single pasted guard or hinge is sometimes used to attach the print to the card so that it is possible at any time to study the back of the print or the watermark by transmitted light, but special care is required in handling prints mounted in this way because when the overthrow is quickly closed the rush of air inevitably forces the print up, so that it may catch in the frame and suffer damage. This scheme is not recommended: four paper guards should be used as a general rule, at all events in museum collections.

(*c*) *The Window-mount.* When drawings occur on both sides of a sheet of paper, the paper may sometimes be split so that the drawings are released and they may then be mounted separately. As the operation of splitting paper is always attended by risk it is generally preferable to adopt, instead, the window type of mount; both pictures then remain visible. In this case the paper is attached only by its edges between superimposed rectangular openings (of appropriate size) in two cards. As the drawings might easily be destroyed if left unsupported, especially where the presence of much ink has rotted the paper, it is usual to mount a cellulose acetate ('Celastoid')[1] sheet at one side so that it forms a transparent support, and, should the paper be very frail, it may be necessary to support it by a similar sheet at the back also.

The window-mount is constructed on the lines of the solid mount by preparing two 'boxes', cutting rectangular openings in them, and 'glazing' each with a sheet of cellulose acetate.

[1] *Celastoid.* Messrs. British Celanese Ltd., Celanese House, Hanover Square, London, W. 1. This type of sheet (cellulose acetate) is preferable to either gelatine or celluloid: it is obtainable commercially under a variety of trade names.

The print is then introduced and the cards fixed together with freshly prepared paste. Thick boards may be necessary if the picture is large, and especially if it is desired to put it in a medium-sized case with other works by the same artist.

Certain other types of transparent sheeting may be suitable for window-mounts, but celluloid should be avoided, as it is highly inflammable and likely to go acid with age; gelatine also, once in favour in the British Museum, is no longer employed as not only has it been found to cockle with age, but it becomes very brittle and liable to splinter like glass, with danger both to the print and the student.

In the passe-partout system, glass is applied to the mount and fixed by the application of an adhesive tape round the edge. Should the glass be in actual contact with the picture, the method is to be condemned as it may encourage mildew; even when the mount affords adequate protection in this respect it is recommended that passe-partout methods be employed only for temporary exhibitions. In this field they serve a very useful purpose as the method is cheap and the display effective.

2. *Receptacles for Storage.*

In the preceding pages it has been necessary to use the terms Solander box and portfolio, and some idea of the respective uses of these receptacles may have been gleaned already.

In a large collection, such as that of the British Museum, it is not practicable to have all prints and drawings mounted; unmounted specimens are stored in portfolios, whilst those mounted on card are kept in Solanders.

(*a*) *Solander Boxes.* (See Fig. 2.) Solanders are designed for strength, lightness, and freedom from any sharp edges which might scratch or otherwise damage the surface of prints. Each box may hold from seventeen to twenty mounted prints, depending on the thickness of the boards. The boxes open book-wise, the back falling to a horizontal position on the table at the same time, so that, when open, it is possible to slide mounted drawings from box to lid and back with ease.

The internal measurements correspond with those of the mounts, a small amount of play being allowed for.

In its simplest form the Solander box consists of a joiner-made wooden case, hinged at the back, covered with cloth and provided with hook-fasteners; the back is provided with a label frame. Heavier varieties may be quarter-bound in leather.

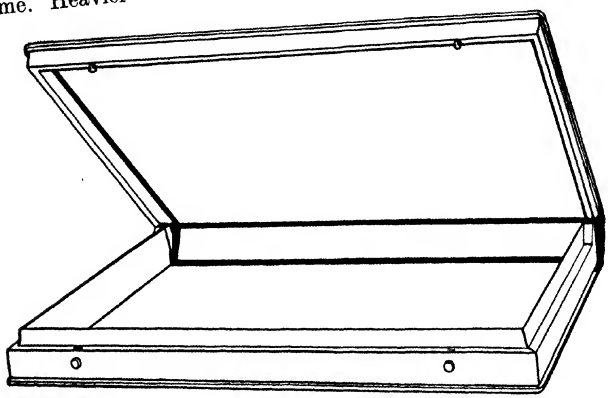
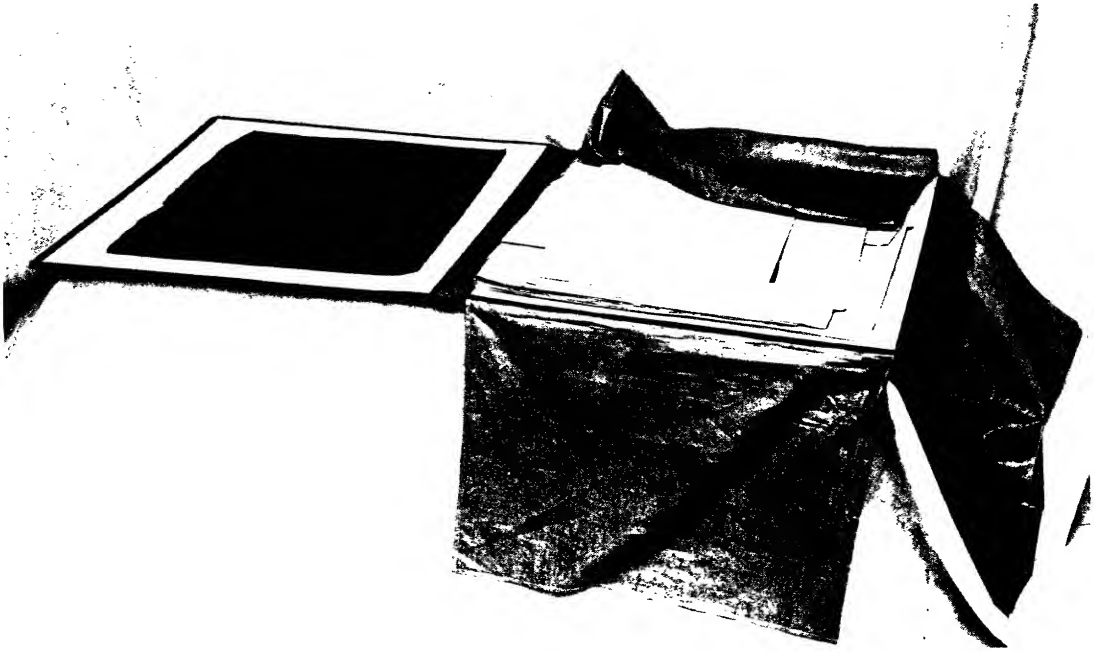


FIG. 2. Solander Box for Storing Mounted Prints

Master collections may occupy a number of such boxes, whilst several artists, when they are represented by few works, may share one box; classification is then alphabetical or in accordance with the modern catalogue lists.

(*b*) *Portfolios.* Portfolios, as a general rule, are required to carry a greater weight than Solanders, and therefore must be strong and rigid. The portfolio is a folding case, one side of which is provided with three canvas flaps which fold across and retain a heap of prints, drawings, &c., in position. Besides the usual few standard sizes required by the general system of storage, a number of assorted out-sizes are necessary, e.g. the British Museum uses among others the following: 33×26 in., $35 \times 28\frac{1}{2}$ in., $37 \times 28\frac{3}{4}$ in., and $51\frac{3}{4} \times 35\frac{1}{2}$ in. The reason for



Portfolio for storing Loose Prints

PLATE II

this is that prints of unusual size are generally retained in portfolio storage. Needless to say, oriental prints have to be catered for separately, as their shapes and sizes are quite distinctive. Some of the larger portfolios may contain as many as 400 prints and drawings, and, when filled they are of considerable weight and require to be stored in a horizontal position, a shelf being devoted to each portfolio. (See Plate II.)

Opinions differ as to the best method of storing Solander boxes. Where little space is available, a vertical system is adopted, at least for the lighter cases. Devotees of the method speak well of it as regards freedom of the prints from mildew; no doubt the arrangement of the cards on end allows access of air to an extent which is not possible when the cards are piled above each other, as they are in horizontal storage. The author prefers the horizontal method, nevertheless, because it seems the more natural, and, as heavy cases are less strained and easier to handle, there is no possibility of damage to prints by bending.

Orientation will determine the design of storage-cupboards. In horizontal storage each Solander is allotted a shelf lined with leather, or, preferably, with linoleum, in order to prevent scratching during the removal and replacement of the case. The shelves are adjustable and are arranged in cupboards which line the walls of the students' room. The cupboards are provided with well-fitting glass doors which are lined with baize or velvet, and the doors have three-way locks so that the turning of the key bolts the door at top and bottom as well as horizontally and in doing so compresses the velvet, dust thereby being effectively excluded.

The timber should be mahogany for preference, there being certain objections to oak, as mentioned above (p. 12).

3. *Atmospheric Conditions.*

In the conservation of prints, drawings, and manuscripts, what is chiefly to be feared is damp. Exhibits of this kind are hygroscopic, and if they are allowed to become damp, they soften and attract mildew. When paper and vellum are kept

reasonably dry there is little fear of their suffering in either of these respects. As these materials will stand elevated temperatures, apparently without being deleteriously affected, it is possible to control the humidity of the air in the galleries within reasonable limits without much difficulty.

When basements or strong-rooms are used for storing manuscripts, too much importance cannot be attached to the question of ventilation, especially if it is suspected that the heating plant may be inadequate; partition walls should be opened up and a current of air made to circulate, if necessary by the use of a shaft ventilator or open-type fan. An ill-ventilated corner, e.g. the back of a book-rack or cupboards may harbour spores which serve as a source of infection over a wide area. In connexion with his studies of humidity Mr. J. A. Macintyre[1] demonstrated that in ill-ventilated corners fluctuations in humidity are reduced, and that when hygroscopic material is present the relative humidity may remain continuously steady. It follows that if the humidity be high it is likely to remain so, and a strong-room or safe or even a particular cupboard may be damp in comparison with the gallery, and may require special ventilation. Mildew is unknown where book-racks, &c., are properly ventilated, and this must be carried out in accordance with certain well-defined principles.

In the students' room there is a temptation to open all the windows in hot weather, but it should be remembered that hot air can carry more moisture than cold air (air is dry during hard frost), and as a large building is slow to heat up internally, the hot air entering by the windows is at once chilled and the relative humidity of the air in the room accordingly increased; this is to be guarded against where papers are stored. The correct procedure in the circumstances is to avoid over-ventilation from outside, and to keep the internal air conditions comfortable by the use of circulating fans. If it is necessary to use artificial means to replace vitiated air, the fresh air should enter the print room from the main block of buildings rather

[1] J. A. Macintyre, 'Air Conditioning for Mantegna's Cartoons at Hampton Court Palace', *Technical Studies*, vol. ii, p. 171.

Students' Room, Department of Prints and Drawings, British Museum, showing storage arrangements for Portfolios and Solander Boxes

PLATE III

than direct from outside, as it is then to a considerable extent tempered, and prints and manuscripts are unlikely to be exposed to sudden increases in humidity.

A check can be kept on the humidity of the rooms and cupboards by the use of a direct-reading or recording hygrometer of the hair type or by a wet and dry bulb thermometer. The hygrometer is likely to require frequent calibration, and the simpler form of instrument is that of the thermometer type. Modern forms of the wet and dry bulb instrument (frequently called psychrometers) are provided with an adjustable scale so that the figure representing the relative humidity of the atmosphere can be obtained at once. To give an accurate reading the instrument should be in an air current of at least 5 feet per second, and some instruments are so mounted that they can be whirled in the hand before readings are taken. Stationary instruments hung in a case should give results close enough to true values for practical purposes if fanned briskly with a piece of cardboard or stiff paper for a few minutes until steady readings are obtained. In the print department or where vellum is stored, the figure for relative humidity should rarely exceed 65 per cent., and in workrooms considerations of comfort alone may be allowed to determine the lower limit.

4. *Display.*

Useful purposes are served by permanent and by mobile schemes of exhibition, and these should be complementary. In evolving a scheme for an exhibition gallery the available space should be used in the main for the development of an elastic scheme which will allow of ready adaptation to the requirements of special exhibitions.

(*a*) *Furnishings.* A system of glazed slope-cases seems to be one of the most satisfactory methods of exhibiting prints, drawings, and manuscripts, because it is elastic and it allows of the quick arrangement of material; the prints are set at a convenient angle for inspection by the public and can be easily and quite adequately illuminated without glare or reflection

from the glass. Any print can be taken out from such cases to be more closely examined or photographed during the course of the exhibition. For the immediate display of new or recent acquisitions under the best conditions, the arrangement is invaluable. Storage facilities can be arranged beneath the cases.

Flat shallow cases may be utilized for the display of unmounted prints, but it is better to make a practice of mounting objects for exhibition even if the mounting be only temporary.

Several pictures, framed or unframed, are sometimes exhibited under one large glass frame, and contingences of space have suggested a means of varying the scheme by the use of hinged wall-frames, folding on the triptych principle, with prints mounted on all five sides (Scottish National Portrait Gallery, Edinburgh). Island-frames, after the same pattern but with many more leaves (multi-leaf display-stands), may be made to carry a large collection of prints, but are generally less attractive to the visitor.

Vertical partition-stands deserve special mention as possessing the virtues of both permanent and elastic systems of exhibition, because, while they may be lined with framed pictures, they serve, in addition, the less obvious but very useful function of dividing up the collection or gallery in a fashion suitable to the exhibition. It is considered important to attract the visitor by varying the appearance of the gallery from time to time, if only as a stimulant for his critical faculties, and in helping to realize such schemes, partition stands are perhaps the most important of any island-type of exhibition-frame or case, when the gallery is sufficiently large to accommodate them.

Various methods of display are shown in the photograph of an exhibition gallery in the British Museum (Frontispiece). This picture indicates how a series of exhibitions can be arranged to run concurrently in one room when the various stands and slope-cases above described are used.

(*b*) *Picture Frames.* Mention has been made of the value of the passe-partout system for temporary exhibitions; for

general purposes, however, something more substantial is required, and choice should be made of a simple oak moulding from which frames can be constructed in the required standard sizes. The wood may be finished in colour or, preferably, it may be rubbed with fine sand-paper and slightly waxed. Mr. I. J. Williams[1] in describing the characteristics of good framing declares that the oak frame should be specially designed to appear narrow when viewed from the front, and yet be sufficiently strong and deep to hold the glass, the double mount containing the print, a three-ply wood back, and also a beading of wood which keeps the whole securely fixed in position. The bead performs the important function of keeping the print or drawing away from the glass; on no account should there be any possibility of contact, even if the print or drawing becomes cockled. The reason for this is that change of temperature may cause condensation of moisture, not always perceptible, inside the glass, and the chance of danger to the paper is greatly increased if it touches the glass. The stability of the ink may also be affected. Pastel drawings are most vulnerable in this respect and, apart from damage by rubbing or staining, the alkalinity of the glass helps to encourage mildew.

When a picture has to be hung against a wall which for any reason is suspected of being damp, pieces of cork should be fixed at the four corners at the back of the frame to allow of free ventilation.

Certain types of specimen, such as large maps which it is not desirable to fold, must be stored in their frames, and these, in turn, may be kept in racks which are channelled top and bottom. Such large frames are normally heavy and unwieldy owing to the weight of the glass; celastoid, when used as a glazing material, has the advantage of effecting a considerable saving in weight.

(*c*) *Protection from Fading.* Most of the material under

[1] I. J. Williams, 'The Preservation, Cataloguing and Educational Value of Print Collections', *The Museums Journal*, February 1919, vol. xviii, p. 125.

consideration is sensitive to light, and there is evidence that the rays which are active in bleaching or staining are not confined to the ultra-violet but extend also well into the visible spectrum.

While glasses can be tinted in manufacture so that they have the property of cutting off most of the active rays, the presence of colour renders them unsuitable for the glazing of cases or picture-frames; a greenish tint in roof lights may be suffered where a slight change in colour values is considered unimportant, but this condition is exceptional and does not apply where coloured drawings are concerned. Much good may be done by the judicious use of screens (velaria) or, during the summer months, of whitewash on the windows.

Direct sunlight must always be prevented from falling on specimens. Sometimes it is necessary to apply textile screens to show-cases or picture-frames. When this is so, the choice of material is determined by the test of opacity, and the suitability of any cloth may be easily discovered by exposing a fragment over sensitized paper in a photographic printing frame. Experiment has shown that the best materials are such as have a felted or matted structure, and velvet is notable in this respect; if for artistic reasons a material of more open weave is preferred, the curtains will require to be lined. The colour of the fabric has no effect on its powers of protection, and may be chosen to harmonize with the furnishings of the gallery.

Because of their sensitivity to light, prints and drawings should be exhibited only for a few months at a time, and illuminated manuscripts should have their pages turned at similar intervals. A group of specialized exhibits, e.g. postage stamps, are not normally exposed to the risk of fading but are either kept in the exhibition gallery in special closed cases or reserved for the use of students only.

The present section would be incomplete without reference to what may be called the hygiene of the collections. The value of systematic routine is nowhere more apparent than in the sense of security which is afforded by the regular

examination of specimens. Material which is seldom consulted should not be entirely neglected and should take its turn in the list of work examined by regular routine. The dusting of floors and cupboards is assisted by any of the vacuum methods of cleaning; floors should be regularly brushed but seldom washed, and a little sawdust (moistened with sweet oil; never with water) is useful for collecting the dust during sweeping.

When these simple precautions are adopted few technical problems are likely to arise in the conservation of prints, drawings, and manuscripts, in temperate climates at all events.

CHAPTER III

DETERIORATION AND RECONDITIONING

In previous chapters it has been necessary to refer from time to time to the action of humidity and of fungus on various constituents of prints, drawings, and manuscripts, and these agents are no doubt responsible for the most commonly occurring forms of decay. Much has been said which bears on the prevention of fungoid attack; a no less important aspect of the subject remains to be considered, namely, how to recognize and to arrest and remove deterioration which is already active. Before describing practical methods of cleaning and restoration, a short account must be given of the main types of staining and deterioration, with special reference to the results of recent researches on the subject.

1. *Mildew and Foxing.*

Paper is said to be mildewed when it is weakened and stained as a result of the growth of minute fungi; such growth takes place most readily when the material is damp. Where prints, drawings, and manuscripts are concerned the damage may be considerable. Pierre Sée[1] has pointed out that some moulds[2] puncture the paper, others tunnel along the tissue, and others, again, seem to work entirely on the surface. Staining is generally increased as the organism develops, either from direct contact with growths which are themselves coloured, or by absorption of coloured compounds formed by the interaction of the growing organism with materials already existing in the paper.

Fungoid growths upon paper are superficially very similar,

[1] Pierre Sée, *Les Maladies du Papier Piqué* (Paris, 1919), also 'Sur les Moisissures causant l'Altération du Papier', *Comptes rendus* (Paris 1917), vol. clxiv, pp. 230–2.

[2] For the purpose of the present study the following conventions are employed. The terms mould and fungi are used indiscriminately to describe organic growths, and paper is referred to as the ground type of the material attacked.

but under the microscope great differences in structure and habit can be noted, and large numbers of paper-infesting varieties have been identified. One area of mildew on a drawing may contain half a dozen different varieties of fungus, and in old growths such heterogeneity may even be observed with the naked eye.

But deterioration may be taking place without any accompanying sign of active growth. One often comes across stained papers bearing no recognizable growths, and in such cases it is difficult and often impossible to say with certainty whether stains are of fungoid origin or not.

For example, every one is familiar with the characteristic brown spotty type of discoloration known as foxing; this term is used to describe a disease which may result, theoretically at least, from many different causes. Brown spots are caused, for example, by the oxidation of metallic impurities (iron) in the paper, and this takes place most easily when the paper is damp. It happens, in the few cases where foxing has been made the subject of scientific investigation, that the spots have been either proved or suspected to be in some way connected with an attack of mould.

So many variable factors surround an attack of foxing that it is not surprising to find great variety in the causes and appearance of spots. The following are some of the factors bearing on the question—the nature of the paper, sizing, loading, ink, &c., and, perhaps not least, the type of fungus. Although it may be that no organism can be detected on old foxed spots, the frequent occurrence of an excess of iron in the spots may point to the pre-existence of moulds of which all trace has since disappeared. Iiams and Beckwith[1] describe

[1] From the results of practical experiment, Iiams and Beckwith have been enabled to reconstruct a chain of operations which leads to a characteristic type of foxing, and briefly it is as follows: Paper-infesting fungi can produce acid from cellulose, and this acid attacks the small quantity of ferrous iron that is contained in most papers as an impurity. Organic iron salts are formed, and these salts collect at various centres (according to the conditions of humidity, &c.) where they eventually become decomposed, yielding, by atmospheric oxidation, the russet

how they had a special paper made which contained iron salts in its specification, and, on exposing this with standard samples of paper and controls under suitable conditions, typical spots appeared much more quickly on the prepared paper than on the others; nor was this all, for in the special iron-containing paper the degree of foxing was found to be considerably emphasized.

A tinted paper of Dutch origin has been examined in the British Museum Laboratory, and was found to be damaged by fungus in quite a different fashion. The paper had been specially made for artists' use from a formula containing enough iron to impart a uniform pale brown or buff colour to the finished material. After storage during three or four years in a rather damp room, clear spots were discovered dispersed in the coloured ground of the paper, in the manner of fox marks, and these were so disfiguring as to render the paper unfit for use. The size had decayed where the paper was spotty, and this is characteristic of true foxing, i.e. the spots behave like blotting-paper and absorb moisture when the paper is wetted, appearing translucent when held against the light. When tested by chemical means, the clear spots were found to be free from iron, or at least to contain much less than the paper where it was unaffected, a result, as regards iron distribution, which is the converse of that obtained by Iiams and Beckwith.[1] This phenomenon might be referred to as negative foxing.

foxed spots which commonly consist of oxide and hydroxide of iron. T. M. Iiams and T. D. Beckwith, 'Notes on the Causes and Prevention of Foxing in Books', *Library Quarterly*, vol. v, no. 4, Oct. 1935, pp. 407–18.

[1] In making such tests one has to be careful to avoid jumping to hasty conclusions for the following reason. When foxy paper is examined for the presence of iron, let us say, by immersing it in a weak solution of potassium ferrocyanide, the immediate effect is that the spots turn blue because at these points the size is destroyed, absorption is immediate, and a positive reaction is obtained. After a time the trace of iron which is distributed throughout the paper begins to react and it may well happen that a general stain of deeper blue than that given by the spots will be obtained on standing, the final conclusion being that the spots are in fact deficient in iron. In a hasty examination this point would

It would seem that fungus may attack a paper containing iron, either causing it to become badly foxed with accumulation of iron oxide in spots (positive foxing) or giving rise, instead, to colourless spots (negative foxing) which have somehow become deprived of the iron originally present. The two forms of mildew are doubtless caused by the action of different fungi, but the distribution of spotting is similar, and in each case the sizing of the paper has also suffered.

The individual action of certain organisms was demonstrated in a damaged book which was sent to the writer from Hong Kong for examination. In this case the entire sizing of the paper had been completely destroyed, probably by chemical action (hydrolysis and oxidation), with a resulting loss of flexibility so extreme that when the pages were turned they fractured like thin sheets of glass. On the whole the pages were fairly clean (staining did not accompany the main attack) but many leaves bore characteristic fox marks, and sometimes associated with them on the same page were spots which were whiter than the paper, and corresponded in nature to those described above as negative foxing. In the present instance it was not possible to recognize the presence of organisms in either the positive or negative foxing—both were undoubtedly of some age—but the nature of the attacks strongly suggested a fungoid origin.

Spotty effects are often found on paper which has been kept in contact with stained material (as on tissue guard paper in books), and sometimes they result from the oxidation of specks of impurity in the paper itself.

2. *Moisture and Fungi.*

It is common knowledge that the active growth of fungus is generally associated with a comparatively high degree of humidity, and the fact that paper and vellum are hygroscopic

be missed. In the case of the Dutch paper a deep blue circle with a pale centre was obtained when a drop of the reagent was applied to the actual spot, and, on immersion, the paper was dyed blue whilst the spots remained pale.

and tend to absorb and retain moisture explains to a great extent their proneness to become mildewed. There is also an upper limit, however. In experimenting with papers impregnated with a moist nutrient fluid, Iiams and Beckwith found that growth did not take place until evident moisture had dried out, and, indeed, several weeks elapsed before typical foxed spots appeared. Groom and Panisset[1] found that at 25° C. (or laboratory temperature) no growths of *P. chrysogenum* Thom could be obtained below a relative humidity of 72·6 per cent. The former workers in checking these results report no germination below 75 per cent. relative humidity, but they found marked growth to take place above this figure. (The corresponding temperatures are not stated.)

While such observations are important in serving as a guide for desirable conditions in a library,[2] there remains the fact that certain organisms (of which the particular one mentioned above and studied by Groom and Panisset is typical) can live in air which is comparatively dry. They have the property of being able to absorb an amount of water from the surroundings which is adequate for the requirements of growth. It would seem that even under approved conditions the possibility of certain forms of attack must not be overlooked. In summarizing their results the authors state in regard to this property of *P. chrysogenum*, 'In libraries it (i.e. this fungus) may help the spread of mildew, first directly, because conidia germinate in the drops, and secondly, by moistening the confined air between the mildewed sides of closely packed books.'

Inadequate ventilation is a common cause of mildew, and the importance of good ventilation can hardly be over-empha-

[1] P. Groom and Térèse Panisset, 'Studies on Penicillium chrysogenum Thom in relation to Temperature and Relative Humidity of the Air', *Annals of Applied Biology*, vol. xx, no. 4, pp. 633–60, 1933.

[2] 50 per cent. relative humidity at a temperature of 70° F. (21° C.) (Huntington Library, San Marino, California). See also *Mouseion*, 25–6, p. 125; Plenderleith (*Preservation of Antiquities*, Museums Association, London) states that where no installation for artificial conditioning of the atmosphere exists, the temperature may be allowed to vary for 50° to 75° F. (10° to 24° C.) and R.H. from 40 to 60 per cent.

'Foxed' Engraving and wooden backboard showing that spots do not appear opposite the central crack on the board

PLATE IV

sized and has already been referred to in connexion with Storage and Framing. One can study the effects of bad ventilation by observing how the foxed marks are distributed in books and papers which have been tightly packed together for a long period. An instructive example is afforded by the engraving (Pl. IV) which had been framed with a backboard made in two pieces; spots are least evident along a horizontal line opposite the junction.

3. *Stains caused by Mount or Back-board.*

It may well be asked what is the most suitable kind of backboard to use in framing. A single sheet should be employed. Strawboards and coloured millboards should not be used as they are likely to be easily contaminated or infected by spores. The practice of using thin oak boards is to be condemned because such boards give rise to brown stains and knot-marks on the paper which may cause irreparable damage. These stains are amongst the most resistant which the restorer has to deal with. Such disadvantages do not attend the use of white plywood, and if this substance be used, pieces should be chosen which are free from knots and blemishes—unless these are previously covered by tin-foil, using a little flour-paste. The best backing is, no doubt, strong white card of good quality such as is used for cutting mounts. The blanks cut from the centre of the larger mounts may be used for backing picture frames of smaller size.

4. *Sterilization.*

From even a slight acquaintance with the subject, it will be realized that the terms 'mildew' and 'foxing' are descriptive rather than specific, and an exact diagnosis is often impossible. The distribution of spores in the atmosphere, in dust and by contamination, is so widespread that to maintain complete sterilization is an ideal not realized in practice. How, then, can damage be prevented? Let us examine the conditions.

When the mycologist wishes to grow a culture of mould he inoculates a moist nutrient medium with the appropriate

spores, plugs the culture-tube and places it in a dark oven for a day or two at a temperature of about 40° C. (104° F.), this being the optimum temperature at which moulds grow. The organism is then not long in making an appearance.

If the development of spores is to be prevented in prints, drawings, and manuscripts, and if existing growths are to be rendered inactive, it is necessary to avoid dampness, to destroy if possible the nutrient value of the material, and to allow for free exposure to light and air at least for a limited period of time.

We have noted that spores occur almost universally distributed (we cannot prevent this), and further that it is not possible in many cases to say whether damage to papers has, or has not been, caused originally by their action. Hence, the value of establishing some routine method of sterilization which can be applied generally, irrespective of diagnosis; and which can be applied alike to all forms of prints, drawings, and manuscripts with the knowledge that when fungoid growth is present it will be effectively dealt with, the process itself being innocuous to the material which is attacked. The problem is obviously easier with single sheets than with closed books which may normally be closely packed together, but there is no reason why even books should not be amenable to some similar form of treatment.

Of the various factors under control, the first is humidity. Sterilization by desiccation is, however, impractical, whether it be by the agency of heat, cold, a vacuum, or organic solvents, because such dehydration would ruin papers and documents.

The following may be regarded as the characteristics of an ideal method of treatment:

1. It must be adequate for the purpose in view.
2. Neither the substances used nor the process of sterilization should in any way cause damage to the picture or document, either immediately or at a period subsequent to treatment.
3. The liability to accidents of any kind should be negligible.
4. The materials and methods should, if possible, be simple and within the reach of all.

One of the simplest methods of treatment, it would seem, would be to expose papers to sunlight. This is effective but not always convenient, and it may be injurious because of the fading propensities of certain pigments and inks. Hübner (*Mouseion*, 27–28, p. 245) has recommended exposure to ultra-violet rays from a lantern. The present writer has used this method and found it convenient and effective, but he considers that its disadvantages outweigh its merits for general use, because, as in the case of sunlight, there is every chance of certain pigments changing colour or fading. One has to know one's lantern, and standardize conditions, and for the expert, as for the amateur, the question of deciding as to a suitable minimum dosage must ever be attended with uncertainty.

The possibility of controlling the nutrient medium is the next question for consideration.

We cannot change the sizings of papers or the constituents of paints or inks, but it is instructive to notice that some kinds of objects seem particularly suited to the requirements of fungi while others are apparently avoided by them; materials may be divided, in fact, into those which are nutrient under normal conditions and those which are poisonous, and there are degrees of intensity in both categories. It has been found, for example, that among sizing materials alum and resin have an inhibitory effect upon growth and discoloration (Iiams and Beckwith), whilst ordinary gelatine is, of course, easily attacked. Again, the action of different sterilizing agents varies greatly in intensity, and the problem resolves itself into choosing a fungicide and a method of application which will to the greatest degree satisfy the conditions which we have established as being safest and best.

The first consideration is: Shall the fungicide be a solid, a liquid, or a gas? On theoretical grounds, a gas would find its way most quickly to the seat of infection, which may be deep in the tissue; the vapour of a boiling liquid might serve, if it were not that on condensation the liquid would be finely dispersed in the paper. An easily volatile solid is preferable because its vapour functions as effectively as any other gas,

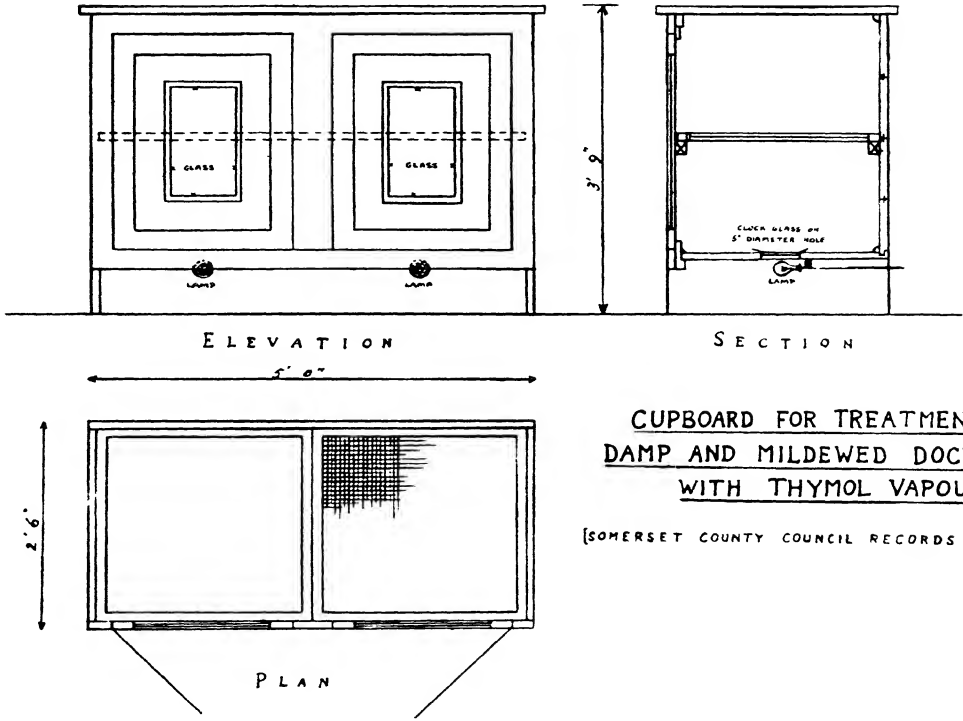
and the trace of solid remaining in the tissue for a short time after treatment may even be an advantage.

There are doubtless many solid bodies which are suitable for this purpose, but among them thymol is pre-eminent on account of its low temperature of melting (49–50° C.) and easy volatility, and because it is readily obtainable in a pure condition. It has been more thoroughly tested as a fungicide for prints, drawings, and manuscripts in the museum than perhaps any similar substance, and the limits of its efficiency with different types of infected materials are well known. The sterilization of museum materials is conducted in a fumigation chamber which will now be described.

5. *The Sterilization Chamber.*

A suitable apparatus for the purpose can be made by adapting an air-tight cupboard or box. To be generally useful the chamber should be large enough to accommodate in a horizontal position anything up to an Imperial sheet (30×22 in.). The print to be sterilized is supported some 2 feet above the bottom of the cupboard on a framework (stretcher) covered with net or strands of tape or twine. In one arrangement, a 40-watt electric lamp is installed at the base of the cupboard, inside, and this emits enough heat to melt the thymol crystals placed in a clock-glass or enamel plate supported on a wire stand some 2 inches above the lamp. It is perhaps an improvement to have the lamp outside the chamber; the clock-glass may then rest on the bottom inside, over a circular hole cut in the base of the cupboard. In such an arrangement the cupboard is raised above the ground on four legs. A large cupboard might require more than one lamp as shown in the drawing (Fig. 3). A cupboard of 16 cubic feet capacity in the British Museum Laboratory is provided with one external 100-watt lamp, and about 1 ounce of thymol is used in sterilizing the contents. These figures may be taken as a rough guide for costing purposes; more exact data are insignificant from the point of view of the efficacy of the process.

In order to sterilize material the current is switched on for



CUPBOARD FOR TREATMENT OF DAMP AND MILDEWED DOCUMENTS WITH THYMOL VAPOUR

[SOMERSET COUNTY COUNCIL RECORDS COMMITTEE]

FIG. 3.

two hours, then switched off. The door should be kept closed for a period of twenty-four hours, and, when many papers are being dealt with, their position in the chamber should be changed and the light then switched on thereafter and allowed to burn for two hours as before. Some workers prefer to have glass-panelled doors so that inspection may be carried out without the doors having to be opened, but this refinement is not essential. The heating can be carried on for periods of about two hours every morning for several days, depending on the degree of infestation. No harm has been found to result from prolonged dosage, and the most varied kinds of material and pigments have been subjected to weeks of concentrated exposure in order to determine whether harm may arise. From these experiments it has been found that the method is of general application to prints, drawings, manuscripts, pastels, water-colour paintings, books, &c., but there are a few important exceptions. *Paintings, &c., which are carried out with oils or varnishes become softened under treatment and should on no account be exposed to thymol vapour.* For a similar reason the chamber itself should not be painted inside. With these few important exceptions no damage has been found to be caused to the materials enumerated, or to any paper or vellum when sterilization is conducted with pure thymol in the manner prescribed.

A large number of prints may be treated in the chamber at once, of course, provided they are not placed in close contact with each other. Small manuscripts may be suspended, rolls set up on edge, books stood on end with their pages spread fanwise, &c.

Needless to say, thymol fumigation kills but does not remove the organism or any accompanying stain; the removal of stains is a separate study which will be considered later.

When a case of mould growth has to be dealt with, it is important that spores should not be allowed to blow about the room; if possible, the growth is dusted off into a sink or basin of water and the drawing is then placed in the thymol chamber. If for any reason it cannot be previously cleaned

(e.g. in the case of a pastel), the drawing is placed immediately in the chamber for sterilization and it may be allowed to remain in the cupboard for as long as a fortnight with two or three spells of heating at irregular intervals. After this time the mycelium is picked off with a fine brush, and marks are easily concealed by a few dextrous touches with a stump.

One final point concerns suggested variations in the treatment. The success of the sterilizing action depends on two factors: (1) the concentration of thymol vapour reaching the fungus, and (2) the drying action which attends the slight rise in temperature. While not so effective, it is sometimes convenient to use thymolized paper for interleaving a badly infested book or for applying to the back of a picture before sealing up a frame. This paper is made by soaking white blotting-paper in a freshly prepared alcoholic solution of thymol (strength 10 per cent.) and then allowing the alcohol to evaporate before use. If a stronger solution is required, thymol crystals may be melted into a pile of absorbent paper by the use of a hot iron.

It will be obvious that no permanent immunity can be expected from sterilization by thymol. Indeed, it is one of the advantages of this reagent that all trace of it disappears from the paper in a day or two: otherwise it would be impossible to give the necessary assurance that no harm will arise from thymol treatment in course of time. As the protection afforded by thymolizing is of such short duration, it must be borne in mind that even sterilized objects will be subject to further attack of mildew if returned to the same conditions as formerly. When fungoid growths are first discovered it is of the utmost importance to try to find the cause of the malady. It may be necessary to wash out cupboards with carbolic soap or lysol and dry with electric lamps, and to make ventilation holes in doors or around the sides of exhibition cases. If spots begin to appear on the open pages of a manuscript whilst it is on exhibition, this is a sure sign that the ventilation of the case is faulty, and this should be rectified before the sterilized objects are returned.

CHAPTER IV

AN OUTLINE OF PRACTICAL METHODS OF CLEANING AND REPAIR

In any collection of prints or documents the problems of cleaning and repair are so numerous that it would be useless to attempt to give, in small compass, practical instructions which could claim to be comprehensive. But apart from the more complex operations of the bookbinder and delicate manipulative processes which require the specialist, a great variety of simple methods of restoration can be applied in an improvised laboratory by the amateur, and the purpose of the present chapter is to present a series of simple operations in the form of practical instructions which may be carried out in this way.

It is important, moreover, that curators should have some familiarity with the fundamentals of practical treatment in order that they may be in a position to advise and control the work of the laboratory staff.

Technical information may be gained from the study of good traditions in a museum, from the published accounts of practical methods of cleaning and restoration, receipt-books, &c.,[1] but nothing short of practical testing and experience will enable one to assess and select the best methods from the mass of material available.

Successful restoration depends on using the least innocuous process and on knowing when to stop. Old and worthless prints and drawings, &c., should be collected for experimental purposes, and repeated trials made of the various processes in order to discover their merits and demerits. Reagents should

[1] The author's thanks are specially due to Mr. J. R. England and other colleagues in the British Museum Print Room. *Print Restoration and Picture Cleaning* by M. J. Gunn, 2nd edition, 1922 (publishers: 'Bazaar Exchange & Mart Ltd.', London), and *Pictures and How to Clean Them*, by T. R. Beaufort (publishers: John Lane, London), 1926, are two well-known reference books which have been freely used in compiling the present text.

The Mounting Room: Department of Prints and Drawings, British Museum. The principal features are good lighting, ample table space, and capacious sink accommodation with hot and cold water supply

PLATE V

be tested on inconspicuous parts of the work before applying them generally, the milder processes being applied initially and the more drastic only after the most careful consideration of the problem in all its aspects; thus, weak solutions are tried before strong, cold solutions before hot, and mild reagents before those known to be more powerful in their action.

In the following notes certain paragraphs are incomplete in themselves and presuppose familiarity with those which precede them. We are here concerned mainly with general principles, and although specific instructions are given, it is to be understood that they may require modification according to the type of material undergoing treatment: the various methods apply, unless otherwise stated, to the more stable forms of art, drawings in carbon ink, engravings, &c.

A. Laboratory Facilities.

No elaborate apparatus is required. A good arrangement is to have a broad window-bench with long shallow drawers (to contain various grades of paper and card) and a dark cupboard beneath for reagents. Part of the bench top should be lined with plate glass (surrounded by wooden moulding) for the trimming of mounts, and the bench is flanked by a large shallow sink having running water laid on, preferably hot and cold. A thymol sterilizing and drying cupboard can easily be improvised. The following list completes the equipment:

Double saucepan for paste-making.
Porcelain paste-pots.
Large porcelain photographic dishes.
Sheets of plate glass of varying size and weight.
Sheets of good quality white blotting-paper.
Large screw-press. ('Copying press'.)
Drawing instruments, rules, squares, &c.
Brushes for dusting, retouching, and paste.
Architect's soft erasers.
Print-trimming knife and oil-stone.
Flexible paper-knives.
Drawing-boards, drawing-inks, &c.

A good hand-lens.
A fount of type. (Optional.)

B. Examination before Treatment.

The Paper. Examine by transmitted and reflected light, using a lens when necessary. Test the crackle on shaking.

(*a*) Is the paper very porous, soft, or spongy? It may be so soft that it is unwise to use immersion methods of cleaning (see Japanese Prints, par. 15). When paper is moistened it expands, the effect of any size or binding material is weakened, and, if carelessly manipulated in this condition, may easily be torn on account of the matted fibres slipping over each other.

(*b*) Is the paper hard or brittle, or the surface pitted or rotten? The hardness due to size must not be mistaken for strength. Test in a corner with water. Papers which have been in the tropics are frequently so rotten that they will not stand manipulation without fracture. When the surface is pitted, immersion methods should be avoided lest the ink or paint should float away.

Take note of weakened areas, creases, tears, worm-holes, &c.

The Impression. To what category does the print, drawing, or manuscript belong? What is the nature of the ink? Is the technique simple or compound? Is any water-colour present? Does the picture bear traces of having been retouched or treated previously?

These and similar questions must be examined at the outset, and a line of action carefully thought out which will lead to a definite result, known to the restorer from his past experience, before anything further is done.

C. Preliminary Treatment to Isolate the Print when it has been Badly Mounted or Varnished.

§ 1. *Removing Cardboard Backing.*

The card is always removed from the print: never the print from the card.

Cardboard is composed of laminated sheets, and the first operation is to insert a knife at a corner and determine how the board is constructed. A long flat paper-knife may now be pressed in and the laminations successively removed from the back, leaving about two of the constituent sheets attached to the print. In this condition the print is held with the back in the steam of a boiling kettle so that the card becomes quite soft: it is then laid face down on dry clean blotting-paper and the card drawn slowly away by dragging on a corner across the part as yet undetached. In this way, if the card has been sufficiently steamed, it may be removed without straining the print. The print is now laid face down on fresh blotting-paper, and any residual adhesive carefully removed by a clean sponge. If this is omitted the paper will eventually cockle. It may then be allowed to dry between fresh sheets of blotting-paper under a weight (sheet of plate glass).

When, as so often happens, the backing is an inferior brown strawboard, nothing but prolonged washing will soften it. This type of board is not laminated and can only be removed by rubbing it gradually away with the fingers.

§ 2. *Removing Paper Backing.*

When completely laid down on paper a print cannot generally be detached by steaming. Lay face down on glass, sponge the back of the mount with warm water. Now float the picture face upwards on lukewarm water and allow plenty of time for the adhesive to soften before attempting to detach the mount.

Remove residual adhesive and complete operations as in § 1.

§ 3. *Removing Canvas Backing.*

When a print has been laid down on canvas fixed on a stretcher, a sharp knife must be first inserted at one corner and drawn along the edges to remove the canvas and print from the wooden support.

The back of the canvas is then sponged with lukewarm

water, and laid against a wet glass plate, the fabric being made as wet as possible, and the print kept as dry as possible.

When the adhesive is sufficiently soft, clean blotting-paper is laid on the print and the whole inverted and placed for support on a glass plate, the canvas now being worked back from a corner by gently pulling it across the part as yet undetached. If the paper starts to split, part coming away on the canvas, stop immediately, apply very hot water and wait for some time before proceeding.

Complete the operation as in § 1 above.

§ 4. *Removing Varnish.*

A print varnished with an oil varnish may be irretrievable. The removal of spirit varnish is rather a specialized operation, requiring considerable care. The treatment given below may have to be modified to suit certain types of print.

Rub a tuft of cotton-wool in the palm of the hand, damp it, and lightly rub over the varnished surface. After drying repeat the operation, using turpentine instead of water. This clears the picture, which should be examined as to its colours before proceeding further.

(*a*) Test a corner of the print with some methylated spirit to see if this is a suitable solvent. If not—

(*b*) Try liquid ammonia (0·880) diluted with water (1 : 50).

(*c*) Very old spirit varnish is brittle and almost opaque. Boiling water may soften it so that it flakes away. As it cannot easily be controlled, this process is risky with anything other than an engraving.

Support the print on a glass plate and flood it with the appropriate solvent, the action of which may be assisted by a flat camel-hair brush. Fresh solvent should be added repeatedly until it no longer becomes stained with the varnish. The print is now free from varnish, although still more or less tinged a faint brownish yellow. It must be rinsed, then bleached, preferably by a hypochlorite solution (§ 11) and afterwards thoroughly washed (§ 8).

If the print is coloured the greatest care must be taken to

see that none of this is lost by fading during the cleaning. Should this happen the action must be stopped immediately by flooding with water; local treatment would then be indicated.

D. Cleaning by Dry and by Immersion Methods.

§ 5. *Removing Mildew and Dry Cleaning.*

If mildew is present pick off the fluffy surface growths with a soft camel-hair brush, taking precautions to ensure that the spores are not scattered about in the process. Many are unavoidably rubbed into the tissue of the paper.

If dirt is deeply ingrained, the surface of the print may be gently rubbed with a piece of stale (day-old) bread, using a light circular motion, taking the greatest care not to raise the surface of the paper. Fresh crumbs should be used as soon as the bread shows signs of dirt. The print must be sterilized after this with thymol.

Alternatively, use an architect's soft eraser for cleaning. The back should be treated similarly. Although dry cleaning is not always necessary, pencil marks, &c., may become fixed in the paper if it is omitted before the immersion treatment.

Dry cleaning may be all the treatment that is required. The use of organic solvents (petrol, &c.) is not recommended unless in the presence of specific stains (§ 14).

§ 6. *Immersion Methods. Use of Back-sheet.*

The possibility of dry cleaning having been considered, two courses are now open—either to clean the print as a whole by immersing in water or to apply local treatment to remove specific stains (§§ 12–14).

The print requires support when immersion methods are employed. Some workers use a sheet of plate glass, others a back sheet of stiff paper. The print is never lifted from the water by its corners or handled while wet without support. When the plate glass or back sheet is slowly raised out of the water the print is supported on it, and in this way may be

safely handled, moved about, and, as it adheres to the glass, may be turned over without being strained in any way.

Any good clean stout paper will do for a back sheet. Japanese vellum is recommended, and although rather expensive may be used again and again.

A good soaking in cold water will always freshen up a print. After an hour it may be placed in a bath of hot water. Most fly marks and mildew stains will respond to such treatment alone.

§ 7. *Soap Cleaning.*

In cases where a bleaching solution cannot be used, soap may be useful. Carefully test the effect in a corner first. The damp print is laid face down on plate glass, and a little good-quality soap (e.g. White Castile) foam applied by a large camel-hair mop to the back of the print. In larger prints a very soft badger shaving brush is a convenient tool, and if the tips of the hairs only are used without pressure there should be no strain on the surface of the damp paper. The face of the print may be treated similarly with care. All trace of soap must be removed afterwards by thorough washing; if this is omitted the paper may go yellow.

§ 8. *Washing.*

This operation is so important, especially when soap or bleaching agents have been used, that it must be carried out with something of the ritual of the photographic studio.

Lead a slow current of water by a rubber tube to the bottom of the dish containing the print and allow the water to emerge below the glass support or back sheet. The duration of washing will depend on the materials to be removed and on the nature of the print under treatment, but at least an hour should be allowed where bleaching solutions have been employed.

§ 9. *Drying, Removing Creases, Sizing, and Sterilization.*

In order to dry it, the print is laid face downwards on glass while still damp, pressed into contact by a pad of blotting-

paper which removes the excess moisture, and set up to dry slowly in a gentle draught.

Contraction of the paper on drying against the glass will remove most creases and marks of folds.

A weak print would require to be resized at this stage (§ 19 (*c*)).

The foregoing processes comprise what may be regarded as the first stage of general cleaning in contradistinction to purely chemical methods, and in the majority of cases will be all that is required. Unless the print exhibits persistent stains the amateur restorer will not wish to expose his work to the risks which attend the use of bleaching agents.

If no further treatment is necessary the print is now ready for the thymol chamber.

E. Bleaching Processes. Removal of Stains by Specific Solvents.

§ 10. *Choice of Method.*

Bleaching processes are designed to discharge natural colouring matter. This in itself is generally an easy operation, but in the case of prints and drawings the difficulty is to attain satisfactory results without loss of brilliancy in the inks or pigments. The nature of the picture and the stains should determine the best kind of treatment to employ, and experience is here of the utmost value.

Bleaching may be performed by exposure to sunlight or ultra-violet rays. The former has given remarkable results in the case of Egyptian papyri where the writing material is a stable carbon ink. In print cleaning the more practical course is to employ one or other controlled chemical process of bleaching, and certain of these which have been found useful will now be considered.

§ 11. *Bleaching by Hypochlorites.*

The traditional methods of bleaching paper depend on the action of the hypochlorites of calcium and the alkalis. The

former substance, known as bleaching powder (calcium chlorohypochlorite, 'chloride of lime'), is employed in bleaching the raw materials from which paper is made. While this may also be employed in dilute solution for bleaching prints, sodium hypochlorite (liquor sodae chlorinatae, Eau de Javelle, 'Chlorinated soda') finds most favour for this purpose as it is easier to prepare for use.

Sodium hypochlorite should be purchased in a stoppered bottle (marked '10 per cent. w./v. available chlorine') and kept in a cool dark cupboard reserved for such things. It must be diluted with water before use, generally 1:20; in no circumstances should the strength be greater than 6:20. Chlorine is generated in the bath, and this has a powerful bleaching action, discharging the colour from dirt, mildew stains, fly-marks, remains of varnish, &c., so that the paper is apt to become eventually a staring white. (See § 19 (*d*)). The alkaline action tends to soften the paper, and manipulation by a back sheet is essential. The softening may be mitigated to some extent by having at hand a bath acidified with hydrochloric acid into which the print is transferred for a few moments now and again during the bleaching. (One teaspoonful of concentrated hydrochloric acid in a quart of water will be sufficient. 5 c.c. per 1,000 c.c. water.)

Any signatures in iron-gall inks will disappear unless they are protected beforehand. This may be done by the local application of a solution of celluloid in acetone (5 per cent.) applied to the print while it is dry. It may be removed afterwards when the print is again dry by a wash of acetone.

Bleaching is only allowed to proceed until stains become faint. The print is then washed thoroughly (§ 8), and it will be found that the remaining marks gradually disappear.

The well-known trade antiseptic 'Milton' is a useful bleaching agent which may be easily obtained in England. It is a hypochlorite solution of standard specification containing additional salts which, in the case of prints, do not affect the main bleaching action. 'Milton' is diluted with an equal volume of water before use: it may be employed as a bath or applied by

brush, and the subsequent washing with water must be as thoroughly carried out as before.

§ 12. *Bleaching Coloured and Fugitive Prints.*

Many prints and drawings may not be immersed in hypochlorite solution without damage. This applies particularly where colours are present. In such cases the prints are laid face down on glass, and a pad of wet blotting-paper applied to the back for a few minutes and then removed; after this the minimum of bleaching solution is applied to the moist back of the print by a camel-hair brush. It permeates the paper, having a mild bleaching action on the front. After about ten minutes, examine through the glass, and, if the result is satisfactory, wash the print *in situ* holding it against the glass all the time, and at an angle to the running water. Now reverse, using a back sheet, and lay the back of the print (and the sheet) against the glass, allowing a gentle stream of water to run over the picture for a short time. The print is then dried, in this position (i.e. face uppermost), against the glass.

An alternative process is suggested by Gunn (loc. cit.). A folded blotting-paper is impregnated with a rather stronger solution of chlorinated soda, say 4:10, and allowed to become almost dry before being placed around the print and then sandwiched between two sheets of plate glass. This is said to serve well for India-proofs (§ 17). Care should be used when removing the blotting-paper lest it should bring any of the ink away in the process. When prints are such that they cannot be washed after this treatment they should be exposed freely to the air for at least two days before being returned to the collection.

§ 13. *Bleaching by Chloramine-T.*

A much milder form of bleaching agent has recently been applied to the cleaning of prints and drawings, viz. Chloramine-T. This substance possesses the unique advantage that when applied to a print its bleaching properties are soon lost and nothing of a corrosive nature remains on the paper. Washing

may thus be reduced to a minimum or entirely dispensed with. The process is particularly suitable for water-colour drawings, coloured subjects generally, and drawings in bistre and sepia, as the reagent may be applied to those parts of the work which are stained without endangering the whole.

Chloramine-T is purchased in the form of a fine, white, rather insoluble powder, and must be kept in a well-stoppered bottle on account of its instability. Dissolve only immediately before use, 2 grammes in every 100 cubic centimetres of water. Apply the solution to the stain by a soft camel-hair brush, cover by a pad of blotting-paper, and place under a glass plate. After an hour the print should be examined; further applications will be necessary, because the reagent is very mild in its action.

§ 14. *Removal of Stains by Specific Solvents.*

(*a*) *Oil, Fat, and Tar Stains: Pyridine.* (*Local application.*) Pyridine, only the purest form of which should be employed, is an invaluable solvent for old partially oxidized oil and for asphaltic stains, being decidedly more effective than benzol. Care in application is necessary in order to avoid spreading the stain and to prevent action on the medium of the ink.

(*b*) *Wax and 'Candle-grease' Stains: Petrol.* (*Immersion.*) Some of the grease can generally be removed by a blunt paper-knife. The whole print is then immersed in a bath of pure petrol. After soaking a few minutes the stain is rubbed with a camel-hair brush and soon disappears.

(*c*) *Fly Stains: Hydrogen Peroxide, &c.* (*Local application.*) Stippling the spots with hydrogen peroxide in an equal volume of alcohol is often effective. If this fails try Chloramine-T. (See also § 6.)

(*d*) *Tea and Coffee Stains: Potassium perborate.* (*Local application.*) Damp the area. Stipple an aqueous solution of potassium perborate on the stain, the strength depending on the intensity of the stain, and expose to sunlight for an hour or so. This is not entirely without danger to the paper, and if it causes much softening the action should be stopped at once by flooding the part with water.

Ethereal hydrogen peroxide (see (*f*) below) is also useful, and may be tried after a preliminary short exposure to the action of perborate.

(*e*) *Ink Stains.* (*Local application.*) Owing to the great differences in iron gall inks and even in modern inks of the blue-black type no single process can be advocated as certain of success. A number of methods are available. Some of these may be found to bleach most of the stain leaving a yellow tinge in the paper, which in turn may be discharged by an entirely different process and reagent. Some of the possibilities are as follows:

Paint with freshly prepared 2 per cent. aqueous Chloramine-T. If not completely effective after two or three applications, and the subject allows, try chlorinated soda. Washing with water is now essential. If the stain persists paint the area with 5 per cent. aqueous salts of lemon (potassium binoxalate), or 5 per cent. oxalic acid or 10 per cent. citric acid, and then again wash thoroughly. Remember that no tannate of iron could survive any one of these methods without bleaching, and that if coloured matter remains it is likely to be carbon or the remains of some dye. Always stop the action short of absolute bleaching, and take no risks as regards the possibility of rubbing up the surface of the paper. Should the stain still persist when dry, employ ethereal hydrogen peroxide. The trial of bleaching agents in an indiscriminate fashion is likely to be ineffective and to cause damage to the paper.

One further method may be mentioned strictly as a reserve process to be used in case of emergency. It must be regarded as a last resort as it is definitely deleterious to the paper: at the same time it seldom fails. An aqueous solution ($\frac{1}{2}$ per cent.) of potassium permanganate is painted over the stain where it forms a brownish red blotch. After about a minute cover this with an aqueous solution of sulphur dioxide, or a 5 per cent. aqueous solution of oxalic acid. The brownish-red stain disappears immediately, and the paper will be found to have been strongly bleached. Thorough washing after treatment is essential.

(*f*) *Blackened Flake White and Red Lead: Hydrogen Peroxide.* The direct application of a commercial solution of hydrogen peroxide which is sometimes advocated is undesirable, as it is liable to contain corrosive impurities. The solution should be poured on a stucco plate which is then fixed over the print about one-eighth of an inch above it, and left for a few hours. The hydrogen peroxide vapour will clear the blackened pigments.

A method of more general application is to employ an ethereal solution prepared as follows—equal parts of hydrogen peroxide (20 vols.) and ether are shaken together in a glass-stoppered bottle. The liquids are immiscible, the ether eventually remaining above charged with hydrogen peroxide. A large goose-quill brush is dipped into the top layer, and by this means the picture flooded in a series of parallel strokes, the ether volatilizing instantly. The action of the gas may be prolonged by having a piece of blotting-paper at hand to slip over the print immediately after the painting. The bleaching action may be enhanced if necessary by adding a drop of perhydrol to the ether and exposing the print to the fumes of strong ammonia. In this way, and with great ease and rapidity, the print is freshened up without its being wet at all. The technique lends itself to the treatment of books and manuscripts.

This operation must be carried out in a large well-ventilated room free from naked lights, owing to the great inflammability of ether.

The brush should be carefully washed afterwards.

E. Special Kinds of Cleaning and Restoration.

§ 15. *Japanese Prints.*

Few of the ordinary methods of treatment apply in the case of Japanese prints, on account of the soft texture and quality of the paper. It is fortunate that this paper does not appear to be greatly attacked by foxing or mildew: the dirt is generally superficial.

To clean a Japanese print lay it face down on glass and cover with a rather longer sheet of tissue paper (or preferably of Japanese tissue, which is thinner) in such a manner that one end of the tissue projects and can be held against the glass by the hand. With a tuft of cotton-wool apply plain water all over the tissue in a series of light parallel strokes. Sufficient will soak through to make the dust on the print adhere to the tissue, and on carefully folding back the tissue this dirt will be removed. If not entirely successful a very diluted size solution (§ 19 (*c*)) may be substituted for the water, a fresh operation being conducted on the same lines.

When a suitable solution has been found treat the front similarly.

Note. As mauve and heliotrope pigments are generally of vegetable origin and easily damaged, they should never be damped.

§ 16. *Japanese Vellum Mounts.*

The so-called Japanese vellum forms an ideal mount for Japanese prints. Although it is a hard paper the surface will not bear cleaning by the ordinary dry methods as it is very easily rubbed up. A clean, soft sponge or, preferably a tuft of cotton-wool, is dipped in dilute starch solution, gently squeezed and passed lightly and rapidly over the surface. By this means the dirt is picked up and the mount greatly improved in appearance.

§ 17. *India-proofs.*

The cleaning of an India-proof is an extremely delicate matter on account of the ease with which the India paper becomes detached from its mount. Stains should therefore be removed by local treatment if possible.

Reference has already been made (§ 12) to the method of using blotting-paper impregnated with chlorinated soda, a method which lends itself particularly to this type of restoration.

Should the India paper become detached the ordinary

chlorinated soda bath may be applied successively to each sheet, which is then washed.

In order to remount, the print is laid face down on plate glass: the back is pasted all over, taking care to keep the paste off the glass, and the glass is then turned over and placed against the mounting paper which has been previously damped so that the India-proof adheres in its correct position. This is the best that can be done in the unfortunate event of separation: if the two sheets are partially separated they had best be completely detached from each other by soaking and floating them apart. The mounted India-proof is dried superficially by blotting-paper, and after about ten minutes removed from the glass. It is then allowed to dry slowly under a weight protected by sheets of blotting-paper at each side. Should the blotting-paper adhere, it may easily be removed by damping with water.

It should be noted that the sharpness of detail in an India-proof is bound to be lost to some extent when it is necessary to wet the paper for cleaning. Moreover, the difference in expansion and contraction between the India paper and its mount renders it almost impossible to regain the original tension between the two when they are remounted and dried.

§ 18. *Pastel and Chalk Drawings.*

Pastel paintings, especially those on vellum, should be frequently inspected.

When mildew is found growing on a pastel it must be picked off with a fine camel-hair brush slightly moistened with pure alcohol, and the picture then sterilized with thymol. If permanent staining has occurred it may be possible to hide this by spreading the pastel pigment with a stump. Pastels should always be mounted with a sheet of thymol paper behind.

The treatment of pastels by amateurs should be restricted to the above.

When certain types of old chalk drawings (outline drawings on an inferior brown paper) are mildewed, they may become stained in a manner which is very disfiguring owing to the sparsity of pigment. The stains cannot be bleached as the

paper would be bleached also. Float the drawing on the surface of cold water face upwards, and touch the spots after some minutes with a fine brush. If this is not effective remove and try floating on hot water in the same way. This treatment is only possible with old drawings when the pastel pigment has become fixed in course of time owing to the action of moisture on the size of the paper and binding material of the pigment.

§ 19. *Repairs.*

(*a*) *Removing Creases.* When not very bad a hot iron should suffice to remove such disfigurements.

Reference was made in § 9 to the removal of creases by drying the print against glass. In the case of very bad creases Gunn recommends pasting strips of strong white paper $\frac{3}{4}$ in. on the glass and $\frac{1}{4}$ in. on the print all round, so that the tension may be greater on shrinking. Before cutting away the paper when it is dry, a little paste should be rubbed along the line of the crease, and if necessary a strip of similar paper applied as a patch.

Always remember when sticking one piece of paper to another that they should be of the same quality as far as possible: the support must be dry and the paper to be stuck not very wet otherwise warping will occur.

With vellum the problem of creasing and warping is much more complicated, and even prolonged treatment in a press may not be effective.

(*b*) *Tears in Paper and Vellum.* If possible immerse the paper in water face downwards, insert a glass plate beneath, and when the torn pieces have been carefully floated into their correct positions slowly raise the plate and print out of the water. When half dry tap along the joints with the back of a spoon in order to weld the fractured surfaces together. Paste may be added and also a patch, if necessary, taking care that the grains of hand-made papers run in the same direction (see p. 2).

When a Japanese print is broken and much torn it should be completely pasted down on another Japanese paper of similar quality.

Book muslin may be used for vellum and for mending pages in books. The page is pasted thinly, the cloth applied evenly by pasting through the muslin with the brush, and then, after protecting each side by some sheets of blotting-paper, the book is put in a press. This thin cotton material is almost transparent when so applied, if chosen with care: the threads should be single and very thin, and the strands unclogged with dressing.

It is sometimes necessary to fit a patch into a print: pieces of old engravings may be used for this purpose, or if the surface is white, any thin tough paper of similar tone will do, if due allowance is made in the pasting for difference in shrinkage.

(*c*) *Sizing. Retouching.* The paper will require to be re-sized if any retouching has to be done. Parchment size is recommended for this purpose, prepared as follows: A piece of vellum or parchment is cut into small pieces and these are digested with water in a jam-jar placed in boiling water over a slow fire. Alternatively a good gelatine size is made by dispersing 1 sheet of clear gelatine in a quart of water (not more than 1·5 grammes per 1,000 c.c.). Size should always be freshly made immediately before use.

The amount of retouching should not exceed the absolute minimum required to conceal disfigurements due to tears and abrasions of the paper. The method should generally be by stippling save where an engraved line has to be joined up.

(*d*) *Toning.* When one page of a book has been bleached or when one of a uniform series of engravings has been similarly treated, it may appear blanched and uninteresting beside its fellows. This may be remedied in a rule of thumb fashion by staining the paper with stout or a decoction of tea or coffee. Experience will tell which is best, but a preliminary trial on a similar paper will always be necessary to decide the strength.

§ 20. *Mounting Parchment and Vellum.*

Great care is required in mounting parchment and vellum, as contraction on drying is considerable, and if the pasting process is not uniformly carried out, distortion will result.

Parchment must be soaked in water and placed in sheets of dry blotting-paper between glass plates until it appears almost dry while still retaining its suppleness. A thick mounting board is selected, and four guide marks made to show where the print is to be permanently fixed. The print is laid face down on glass, and pasted half an inch all round the edge two or three times. It is then placed in its permanent position on the mount, and the edges pressed down very thoroughly with clean blotting-paper, for it must be remembered that they have to withstand a fair strain as the parchment dries: should the parchment have been too wet when mounted the edges will pull away dragging off part of the mount with them. At this stage any finger-marks should be removed with a damp sponge, and after covering with two or three sheets of blotting-paper four weights are applied over the corners and it is left to dry. It will become as tight and smooth as a drum.

Vellum is treated in similar fashion. The thinnest and finest specimens do not require the preliminary soaking, and may be merely damped by leaving them for a short time in damp blotting-paper between glasses.

APPENDIX

EQUIVALENT MEASURES

Weight. 1 lb. = 16 oz. [= 454 gm. approximately].
1 oz. = 28·4 gm.

Capacity. 1 pint = 20 fl. oz. [= 568 c.c. approximately].
1 fl. oz. = 28·4 c.c.
1 Winchester Quart (W. Qt.) = ½ gallon.
= 2,270 c.c.

Temperature.

Zero Centigrade = 32° Fahrenheit (freezing-point).
100° C. = 212° F. (boiling-point).

Conversion: Centigrade to Fahrenheit
(° C.×9÷5)+32 = °F.
Fahrenheit to Centigrade
(° F. −32)×5÷9 = °C.

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